

INTRODUCTION TO SIGNAL THEORY AND APPLICATIONS OF FOURIER TRANSFORM

Original

INTRODUCTION TO SIGNAL THEORY AND APPLICATIONS OF FOURIER TRANSFORM / Mesin, Luca. - STAMPA. - (2012).

Availability:

This version is available at: 11583/2495583 since:

Publisher:

CLUT

Published

DOI:

Terms of use:

openAccess

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

Contents

I	Theory of Fourier Transform	1
1	INTRODUCTION TO SIGNAL THEORY	3
1.1	DEFINITIONS	3
1.2	FOURIER ANALYSIS	4
1.3	COMPLEX NUMBERS	4
2	SPACE OF SIGNALS	7
2.1	ELEMENTS OF LINEAR ALGEBRA	7
2.2	ELEMENTS OF ANALYSIS	8
2.3	SCALAR PRODUCT	9
2.4	SIGNAL AS COMBINATION OF ELEMENTS OF A BASIS	10
2.5	GRAM-SCHMIDT ORTONORMALIZATION PROCESS	12
3	FOURIER SERIES	15
4	FOURIER TRANSFORM	17
4.1	FROM FOURIER SERIES TO FOURIER TRANSFORM	17
4.2	INVERSE FOURIER TRANSFORM DERIVATION	18
4.3	PROPERTIES OF FOURIER TRANSFORM	20
4.3.1	Linearity	20
4.3.2	Time delay	20
4.3.3	Modulation	20
4.3.4	Scaling in time domain	20
4.3.5	Scaling in frequency domain	21
4.3.6	Convolution	21
4.3.7	Product	21
4.3.8	Duality	22
4.3.9	Differentiation	22
4.3.10	Multiplication by t	23

4.3.11	Integration	23
4.3.12	Parity rules	24
4.3.13	Analytic signal	25
4.3.14	Parseval equality	26
4.3.15	Heisenberg inequality	26
5	LINEAR SYSTEMS	29
5.1	INPUT-OUTPUT RELATION OF AN LTI SYSTEM	29
5.2	TRANSFER FUNCTION	30
5.3	CONDITIONS OF REALIZABILITY	30
5.4	RESPONSE TO A SINUSOIDAL SIGNAL	32
5.5	STABILITY OF A SYSTEM	33
5.6	EXAMPLES OF LTI SYSTEMS	34
5.6.1	RC Low Pass Filter (LPF)	34
5.6.2	Modulation	35
6	GENERALIZED HARMONIC ANALYSIS	37
6.1	ENERGY DENSITY $S_x(f)$	37
6.2	AUTOCORRELATION FUNCTION $R_x(\tau)$	38
6.3	POWER SPECTRAL DENSITY $G_x(f)$	39
6.4	MUTUAL CORRELATION FUNCTION	41
7	PERIODIC SIGNALS	43
7.1	FOURIER TRANSFORM OF A PERIODIC SIGNAL	43
7.2	POWER SPECTRAL DENSITY	44
8	SAMPLING	47
8.1	SAMPLING AND INTERPOLATION	47
8.2	IDEAL SAMPLING AND ALIASING	48
8.3	NYQUIST THEOREM	48
8.4	ANTI-ALIASING FILTER	50
8.5	NON IDEAL SAMPLING	50
9	DISCRETE SIGNAL PROCESSING	53
9.1	DISCRETE SIGNALS	53
9.2	DISCRETE LINEAR SYSTEMS	54
9.3	IMPULSE RESPONSE	54
9.4	TRANSFER FUNCTION AND Z TRANSFORM	54
9.4.1	Properties of Z transform	55
9.4.2	Z transform of the step	56
9.5	INVERSE OF Z TRANSFORM	56
9.6	NUMERICAL SIMULATION OF AN ANALOG SYSTEM	57
9.7	DESIGN OF A SIMULATOR	59
9.7.1	Sampling the analog impulse response	59
9.7.2	Bilinear transformation	59
9.8	NUMERICAL FILTERS	60
9.9	IMPLEMENTATION OF NUMERICAL FILTERS	63

10 DISCRETE FOURIER TRANSFORM (DFT)	67
10.1 POISSON SUMMATION FORMULA	67
10.2 DFT	68
11 STOCHASTIC PROCESSES	73
11.1 INTRODUCTION TO PROBABILITY THEORY	73
11.2 SOME IMPORTANT THEOREMS	76
11.3 RANDOM PROCESSES	78
11.4 STATIONARITY	80
11.4.1 Wide sense stationarity (WSS)	81
11.4.2 Some properties of the autocorrelation function of WSS processes	82
11.4.3 Cyclostationarity	83
11.5 LINEAR SYSTEMS	83
11.6 POWER SPECTRUM DENSITY	85
11.7 ERGODICITY	86
11.8 WHITE GAUSSIAN NOISE	86
II Applications to Differential Equations	87
12 DISCRETE SYSTEMS	89
12.1 SYSTEMS WITH ONE DEGREE OF FREEDOM	89
12.2 SYSTEM WITH N DEGREES OF FREEDOM	91
12.3 MODEL OF A SUSPENSION	94
13 CONTINUOUS SYSTEMS	97
13.1 MODELLING	97
13.1.1 Vibrating string	98
13.1.2 Vibrating membrane	99
13.1.3 Sound Propagation	100
13.1.4 Diffusion Equation	103
13.2 APPLICATIONS OF FOURIER TRANSFORM	104
13.2.1 Vibrating string	104
13.2.2 Membrane	106
13.2.3 Resonance Modes of Sound	107
13.2.4 Diffusion problem	109
III Exercises	113
14 Exercises on signals, orthonormalization and Fourier series	115
15 Exercises on Fourier Transform	123
16 Exercises on LTI Systems	129
16.1 Appendix on block diagrams	139

17 Exercises on sampling	141
18 Exercises on stochastic processes	153
A Tables of Fourier transform	161
Bibliography	170
Index	171